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AN EVALUATION OF A TRIPLE-JOINTED SCREED PAVER AS A SOLUTION TO PAVEMENT RUTTING

MATERIALS INFORMATION
ENGINEERING MATERIALS OFFICE

AN EVALUATION OF A TRIPLE-JOINTED SCREED PAVER

AS A SOLUTION TO PAVEMENT RUTTING

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ABSTRACT

In order to counteract pavement deformation along wheel paths, Dynapac has introduced a triple-jointed screed paving system. The four part articulated screed places a mat with a positive crown set over each wheel path. The extra material placed over the wheel path is rolled flat by the rolling train. Increased compaction in the wheel paths should be achieved, thus increasing the pavement's resistance to rutting.

In the summer of 1986, the Ministry constructed a trial section using the triple-jointed screed paver on Highway 401, east of Port Hope. The section was monitored and evaluated using results from plate and core samples of the pavement. A survey to chart the pavement cross section was taken before and after the construction. The test area results were compared to those from a similar area paved with a conventional paver.

The compaction results from the triple-jointed screed test area, showed that the compaction in the wheel paths was typically 1% higher than the average within the triple-jointed screed test area. Compaction values in the centre of the lane were low, most likely a result of the roller riding high on the crowns over the wheel tracks.

In general, the European Dynapac paver produced a pavement with an average compaction of 1% higher than that produced by the conventional paver used in the control area. Fundamental differences between the two pavers (speed, vibratory characteristics of the screed) may be the reason for some of the difference in the compaction results.

The test results to date are inconclusive. Both areas will be closely monitored in the future and yearly cross section surveys will be done to record any pavement deformation.

In order for further testing to take place, modifications to the triple-jointed screed paver must be made. As it is now, the screed adjustment method is a lengthy trial and error process, not conducive to quick changes.

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TRIPLE-JOINTED SCREED PAVER TRIAL

1.0 INTRODUCTION

Pavement deformation along wheel paths or wheel rutting is an on-going problem on some Ontario highways. Dynapac has introduced a new paving system, consisting of a triple-jointed screed mounted on an otherwise conventional paver, to attempt to counteract the rutting. The articulated screed places extra hot mix over the wheel tracks. Subsequently rolled flat, increased compaction of the hot mix should be achieved in the wheel tracks, resulting in increased resistance to rutting.

In the spring of 1986, the Ministry arranged for a test section to be done using the triple-jointed screed paver the following July. This paper details the construction and the performance of the trial sections to date.

2.0 EQUIPMENT

2.1 Dynapac Articulated Screed Paver

The four part Dynapac screed is used to place extra hot mix over the wheel tracks, using a double crown system. The amount of additional material placed over the wheel tracks can be varied, with a possible maximum of an extra 40 mm at the joint (see Fig. 1).

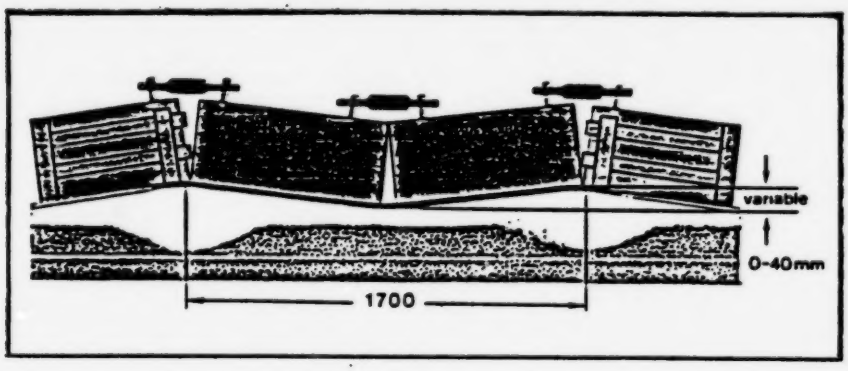


Fig. 1 - The Articulated Four Part Screed

The vibratory screed has an unextended width of 2.5 m. Using the extensions the screed width can be increased to 4.0 m. The outer joints, set over the wheel tracks, are 1.7 m apart.

The outer joints can be set to leave no crown over the wheel tracks, allowing the screed to be used in a conventional manner. The joint adjustment is controlled by a screw spindle across the top of each joint (shown in Fig. 1). A ratchet is used on the spindle to adjust the crown as demonstrated in Fig. 2. The joints are kept in position by lock nuts on the spindle, which are tightened after the crown is set.

Fig. 2 - Crowning Adjustment on Articulated Screed

According to the manufacturer, the screed can be mounted on pavers of all types and in this case, was already mounted on a Dynapac paver for use on the test section. The Dynapac paver (Fig. 3) is built to pave at a speed typical of that used in European paving. The maximum paving speed of the Dynapac is 32 m/min.

2.2 Conventional Paver

The conventional paver used in the test section was the Contractor's Cedar Rapids CR431 paver (Fig. 4). The vibratory screed has an unextended width of 3 m, and a potential paving width of 6.4 m. The maximum paving speed is 46 m/min.

2.3 Rollers

The rollers used on the test section were those in the Contractor's standard rolling train. The train consisted of a Dynapac steel drum vibratory roller (CC42), and a Hyster rubber-tired roller.

Fig. 3 - The Dynapac Paver with the Triple-Jointed Screed

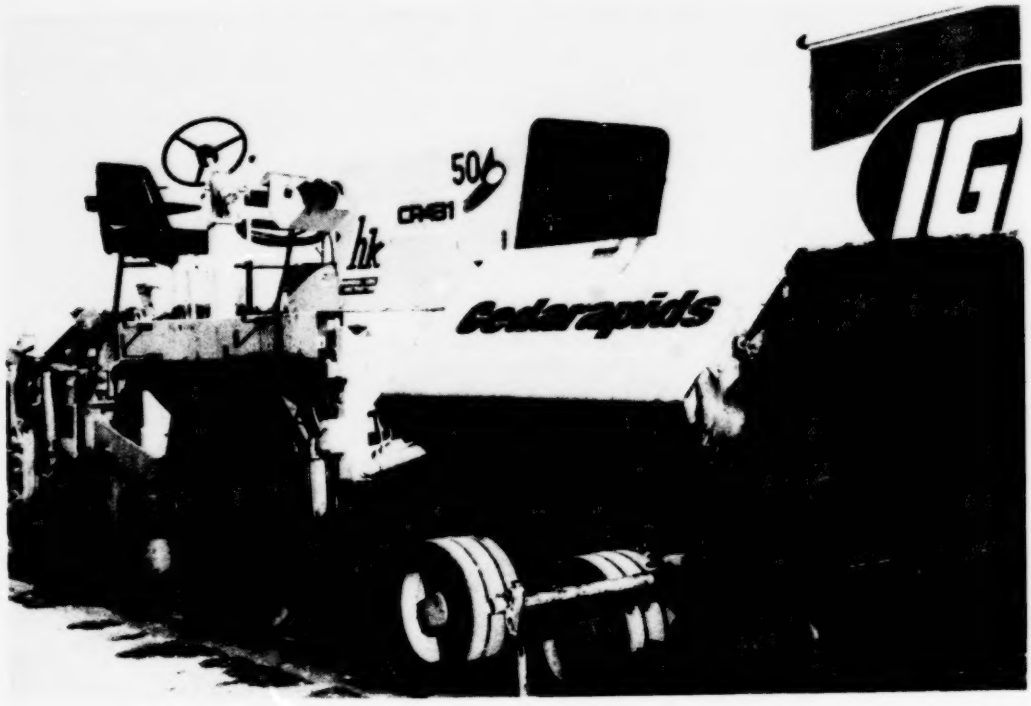


Fig. 4 - Cedar Rapids Paver CR431

3.0 TEST LOCATIONS

The contract selected for the triple-jointed screed paver trial was Contract 85-69, a rehabilitation contract on Highway 401, east of Port Hope (see Fig. 5). The pavement rehabilitation was done on rutted sections in both east and westbound driving lanes, over a length of 51 km. The contractor for the work was Harnden & King.

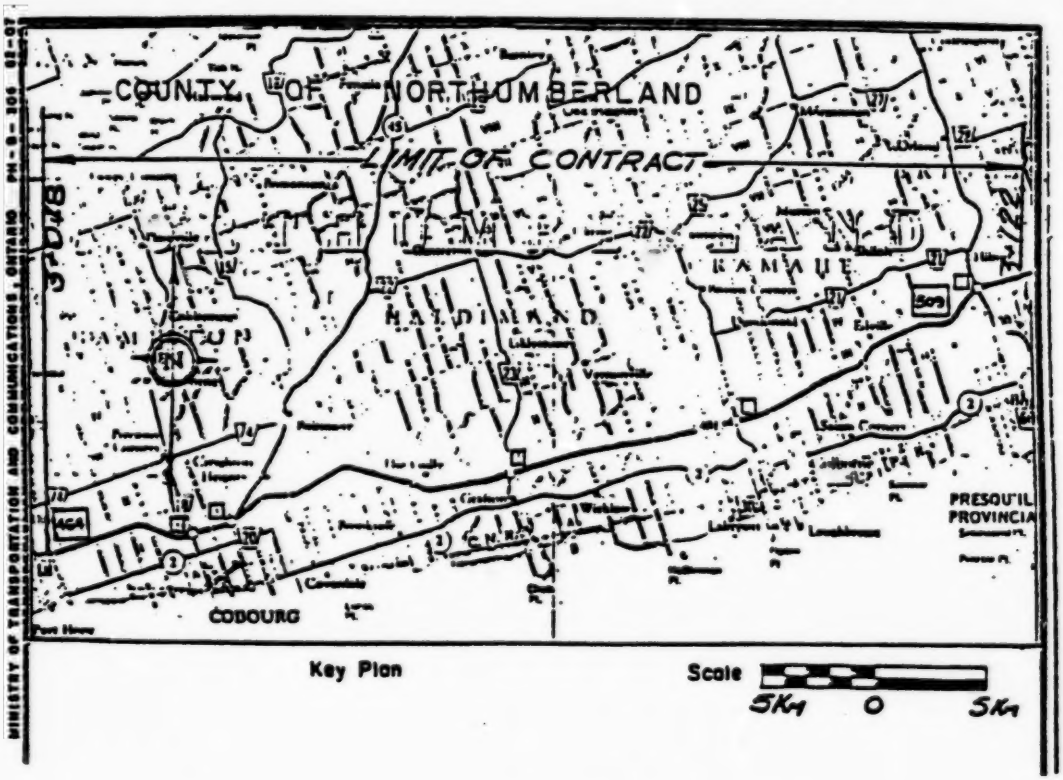


Fig. 5 - Location of Contract 85-69

The rehabilitation method on this job consisted of cold planing 90 mm of the existing pavement and replacing it with 50 mm of recycled hot mix (RHM) binder course and 40 mm of RHM surface course.

3.1 Test Areas

The trial consisted of three different test areas located in the eastbound lane(s) of Hwy. 401 from station 15+450 to 16+950 in Hamilton Township. A schematic diagram of the test areas is found in Fig. 6.

Each of the three test areas was 500 m long, and paved using the same mix design. The surface course was an HL-1 mix, with 25% reclaimed asphalt pavement (RAP). The coarse aggregate was 3M Havelock traprock, and the fine aggregate a blend of Roger's Pit sand and 3M Havelock sand.

3.1.1 Test Area 1

This test area consisted of cold planing 40 mm of the existing pavement and replacing it with 40 mm of HL-1 surface course using the Contractor's conventional paver. This area covered only the driving lane and the 0.5 m shoulder. It extended from station 15+450 to 15+950. (B1*)

3.1.2 Test Area 2

In this area, 40 mm of existing pavement was replaced with 40 mm of HL-1 surface course using the Dynapac paver with the screed set to provide extra material in the wheel tracks. (The amount of material was determined by field trials as detailed in 4.1.) This test area covered the driving lane and the 0.5 m shoulder, and extended from 15+950 to 16+450. (B2*)

3.1.3 Test Area 3

In this area there was no cold planing. A 40 mm overlay of HL-1 was placed in the driving lane with the screed set at an articulated position. The overlay in the adjacent passing lane was placed using the conventional paver because no wheel rutting was present. This area extended from 16+450 to 16+950. (B3*)

* identification of test areas as per signs south of the beginning of each area at the fence line

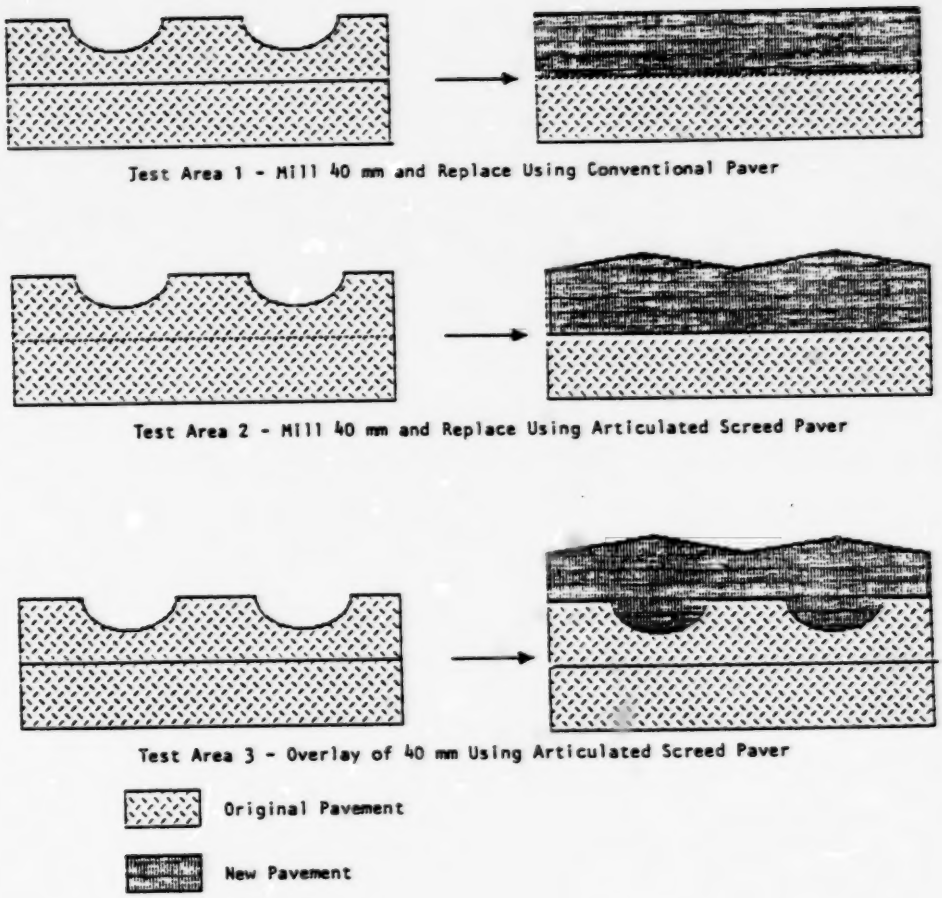

Test Area 1 - Mill 40 mm and Replace Using Conventional Paver
Test Area 2 - Mill 40 mm and Replace Using Articulated Screed Paver
Test Area 3 - Overlay of 40 mm Using Articulated Screed Paver
Original Pavement
New Pavement

Fig. 6 - A Schematic of the Test Areas (pre-rolling)

* not to scale

4.0 CONSTRUCTION

4.1 Preliminary Field Trial

On Friday July 4, 1986 the Dynapac paver, brought in from New Jersey, arrived in Harnden & King's yard in Coburg. A Dynapac representative was at the yard during the following week to assemble the paver and ensure it was in good working order.

A preliminary field trial took place on July 14, 1986 in order to adjust the height of the outside joints. The intent was to find the maximum height of crown placed over the wheel tracks that could be rolled flat by the conventional rolling train.

The process for adjusting the crowns was that of trial and error. The Contractor's crew experimented with the paver on the binder course, with the screed flat until the paver was operating smoothly and they were familiar with the new machine. The centre crown was set. The process was very time consuming because for each minor screed adjustment the paver must be stopped and the screed lifted clear of the hot mix. It is not designed to be adjusted while the paver is in motion. A straight edge was laid across the pavement to observe the result of each adjustment (Fig.7).

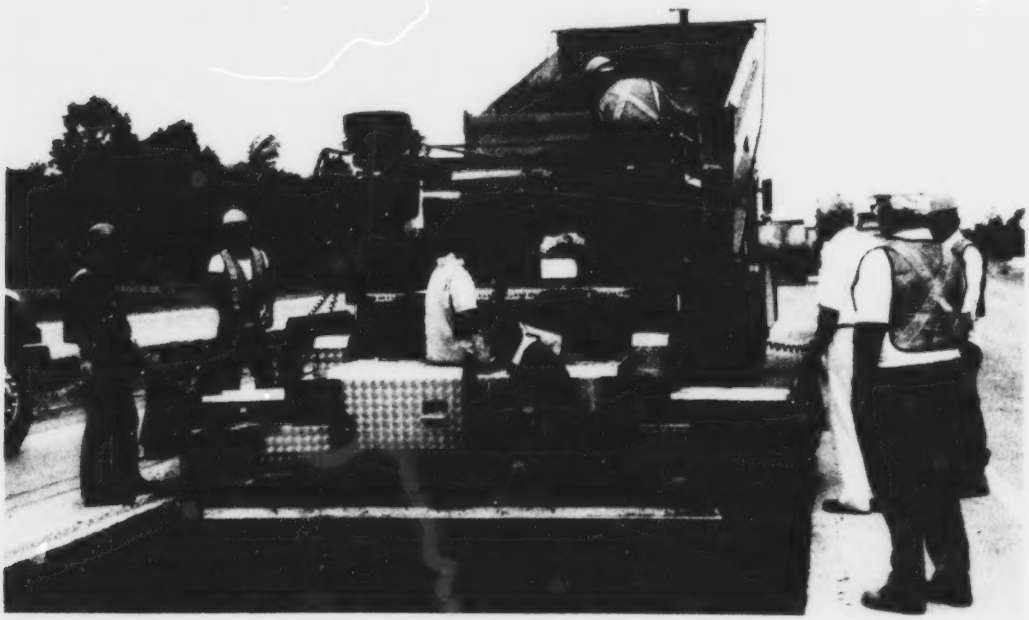


Fig. 7 - Crown Adjustment Process

Once the centre crown was set, the outer crowns were set independently by the same trial and error process. After the rollers completed their passes, a straight edge was laid across the pavement to see if the crown could be rolled out, and adjustments were made accordingly. The outside crowns were set a little lower than that which would be rolled flat because the binder course was 50 mm, versus a 40 mm surface course.

Because of the difficulty setting the crown heights, the paver was left untouched until the actual test section construction. The 40 mm overlay in the passing lane in Test Area 3 was originally to be done with the Dynapac paver set with no outside crowns, but was done with the conventional paver to avoid a lengthy re-adjustment time.

4.2 Construction of Test Areas

The test areas were all paved on Wednesday July 23, 1986. It was a sunny day with a high temperature of 27°C. All of the milling in the test section had been done the previous day. The driving lane was closed to traffic by 6:00 a.m.

Throughout the construction of all three test areas, plate samples and bagged samples of the hot mix were taken for laboratory testing.

4.2.1 Construction of Test Area 1

Paving of Test Area 1 began at 8:30 am. The 40 mm surface course was placed with the Contractor's conventional paver (Cedar Rapids paver shown in Fig. 4). A typical centre crown of 6 mm was set on the screed.

This area was completed without complication within 2 h.

4.2.2 Construction of Test Area 2

The 40 mm HL-1 surface course was placed with the triple-jointed screed paver set at an articulated position (from Preliminary Field Trials 4.1).

The Cedar Rapids paver was moved off the driving lane at 10:30 am and the Dynapac paver was used. A Dynapac representative was not on site to advise in the operation of the machine and the crew was not familiar with all of the controls. This led to a few false starts, but after an hour the paver was running smoothly and producing a mat that appeared acceptable (Fig. 8).

The height of the outside crowns was 7 mm before rolling (Fig 9). The crowns were flattened out by the rolling train.

Because Test Area 3 consisted of an overlay, the milling of the last 20 m of Test Area 2 was gradually tapered up to meet the original pavement at the beginning of Test Area 3.

Test Area 2 was finished by 1:30 pm.

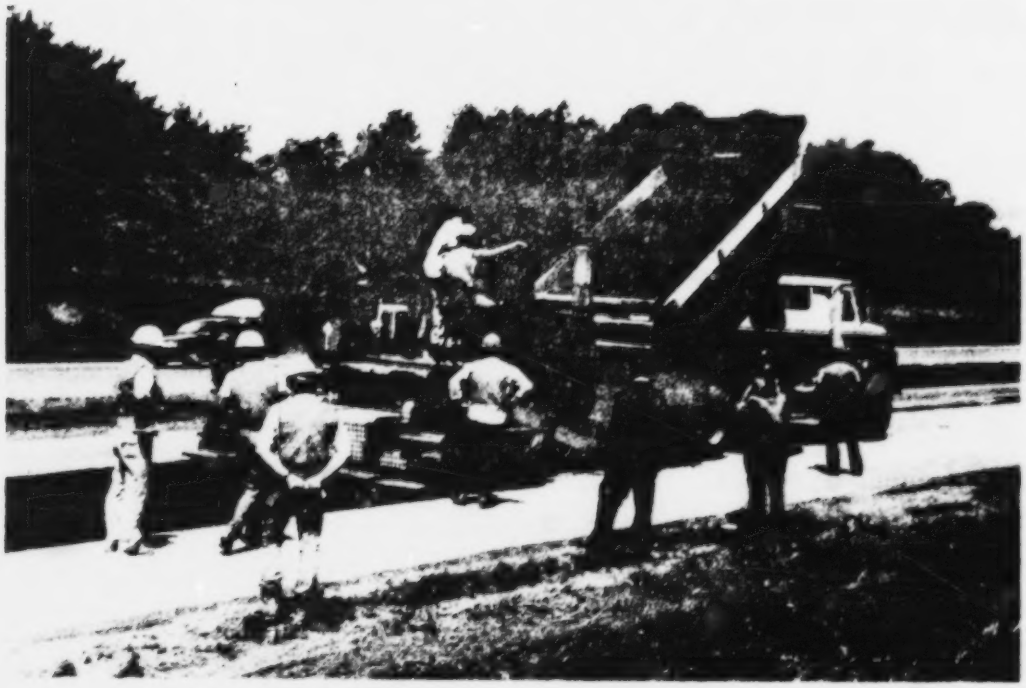


Fig. 8 - Paving with the Dynapac Paver

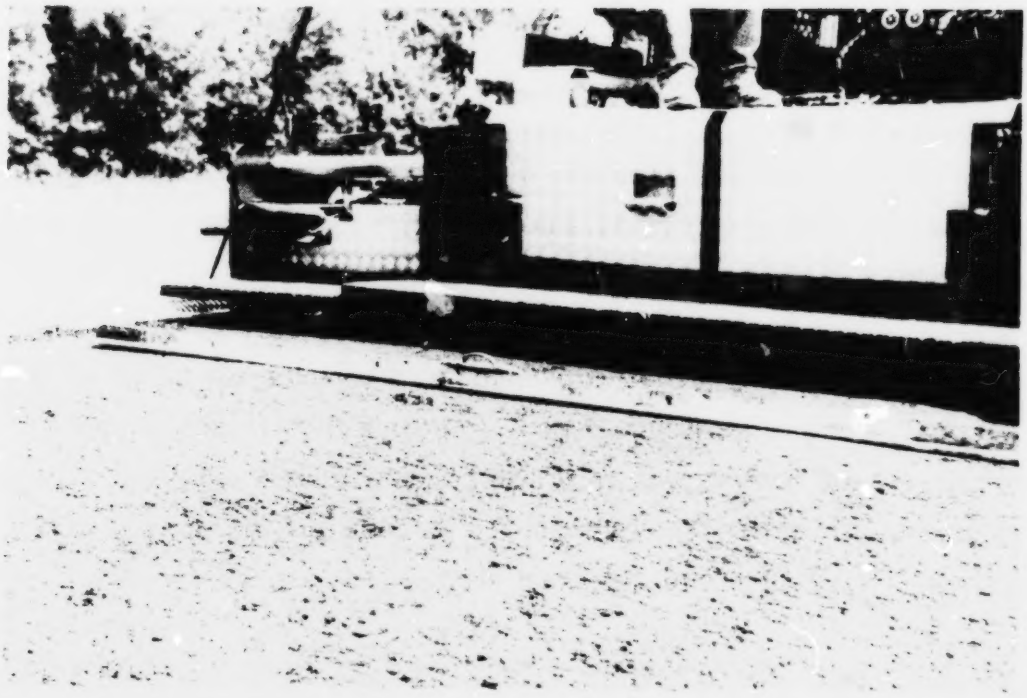


Fig. 9 - The Crowns Placed by the Articulated Screed Paver

4.2.3 Construction of Test Area 3

An overlay of 40 mm of HL-1 mix was placed across both lanes. The Dynapac articulated system was used in the driving lane and the Cedar Rapids paver in the passing lane.

The driving lane was paved in 2 h, and without any difficulty. At 3:30 pm the traffic through the test section was switched on to the driving lane, closing the passing lane. The 500 m long overlay was then placed in the passing lane using the conventional paver. The Dynapac paver was not used in order to avoid the re-adjustment time needed to set the outside crown height to zero. The Cedar Rapids paver completed this area in 45 min, paving much quicker than the Dynapac machine.

5.0 LABORATORY AND FIELD RESULTS

5.1 Laboratory Testing of Plate Samples

During construction of the test section, nine plate samples were taken of the hot mix. The plate was laid in front of the paver to get a sample of the mat being placed. Three samples were taken in each test area, their locations determined by random numbers.

The purpose of the plate samples was to monitor the properties of the hot mix in each area. The material from the plate samples was tested for % voids, flow, stability, % voids in mineral aggregate (VMA), and % asphalt cement. A sieve analysis was performed on the extracted aggregate. The test results (Appendix 1) indicate that the properties of the hot mix were consistent throughout all three test areas and complied with the mix design.

5.2 Compaction and Thickness Test Results

Fifteen cores were taken from each of the three test areas by the Ministry's coring crew. The location of the cores by station was determined using random numbers, and at each station selected, a line of five cores was taken across the driving lane. A core was taken in the centre of the lane, one in each wheel track, and one outside of both wheel tracks. At each station the cores were staggered along the lane over 3 m. Three lines of five cores apiece were taken in each test area. The core sample locations are listed in Appendix 2.

Each core was tested at the MTC Downsview laboratory to determine the % compaction and thickness of the surface course. (The test results are tabulated in Appendix 2). The average compaction of the test section was 98.7% with an average thickness of 49 mm.

Arranging the core results according to the test area and the position of the core within the lane, the average compaction and thickness was calculated for each position in each test area (Appendix 2). The result is summarized in Fig. 10.

Test Area 1 - Mill and Replace 40 mm with Conventional Paver

	(Inside)		(Centre)		(Outside)
Offset (m):	0.31	0.91	1.83	2.74	3.35
% Comp:	97.8	98.8	98.3	98.9	97.6
Thick (mm)	50	50	48	46	41

Average compaction in area: 98.3%
Average thickness : 47 mm

Test Area 2 - Mill and Replace 40 mm with Triple Jointed Screed

Offset (m):	0.31	0.91	1.83	2.74	3.35
% Comp:	99.2	99.6	96.9	100.0	98.4
Thick (mm):	53	55	50	47	37

Average compaction in area: 98.8%
Average thickness : 48 mm

Test Area 3 - 40 mm Overlay with Triple Jointed Screed

Offset (m):	0.31	0.91	1.83	2.74	3.35
% Comp:	98.3	100.1	97.8	100.1	98.7
Thick (mm):	46	52	45	46	41

Average compaction in area: 99.0%
Average thickness : 46 mm

* offsets are measured from centreline of eastbound lanes
**overall average compaction 98.7%

Fig. 10 - Summary of Core Results by Position and Test Area

5.2.1 Test Area 1

Test Area 1 had an average compaction of 98.3% and thickness of 47 mm. The centre cores had an average compaction of 98.3% with the compaction in both wheel tracks about half a percent higher, and at the sides about half a percent lower than the centre cores.

The higher compaction in the wheel tracks in this area, might be explained by the schedule of the coring operation. The initial core samples taken by the contractor immediately following construction, were piled on top of one another before testing. As a result, the majority of the cores crumbled and were unsuitable for testing. All three test areas had to be re-cored by the Ministry's coring crew, this second set taken a month after the pavement had been placed. Therefore, traffic had been on the test section for a month before the cores were taken, increasing the compaction of the pavement primarily in the wheel tracks.

The centre cores had a higher percent compaction than the outside cores because of the additional material placed by the crown in the centre of the screed (6 mm).

The cores taken at an offset of 3.35 m were near the outside edge of pavement. This edge was unconfined, and therefore had a lower percent compaction than the average of the cores taken at centreline. Also, the average lift thickness near the edge of pavement (41 mm) was much less than that at the 0.31 m offset (50 mm) where existing pavement had to be met (adjacent passing lane). However, as shown in Appendix 2, only one core sample thickness was available in this position.

5.2.2 Test Area 2

In Test Area 2, the compaction results in the centre were relatively low. Most likely the roller drum was riding high on the outside crowns, thus compacting the centre only slightly.

The samples taken in the wheel tracks did show a compaction about 1% higher than the average for the test area, probably a result of both the traffic on the section and the extra material placed in the wheel tracks.

The cores taken at an offset of 0.31 m and 3.35 m from the centreline of the eastbound lanes were less dense than those taken from the wheel paths. Again, the cores from the outside unconfined edge were thinner and did show lower compaction than those cores taken from the inside edge of the driving lane.

5.2.3 Test Area 3

This test area was the overlay paved with the triple-jointed screed. Here extra material was crowned over the wheel tracks, however the depressions existing in the wheel tracks were not removed (ie. milling was not done).

As in Test Area 2, the centre cores showed a relatively low compaction. Again this was probably due to the edges of the roller riding high on the crowns over the wheel paths. However, in Test Area 3 the effect of the crowns on the roller was reduced because the depressions were left in the pavement (as compared to Test Area 2). The severity of the rutting determines the effect of the crown over the wheel paths, and the amount of contact the roller has with the centre of the driving lane. This is evident in the results from the cores taken at Station 16+654. At this location the rutting was minimal, and the compaction of the centre core was only 96%. In the two other cases, the rutting was deeper (refer to 5.3 Pavement Template Survey), and the centre core compaction was higher (98.3 and 99.2%).

The compaction values found in both wheel tracks were consistently high, with an average of 100.1%. This high compaction was due inpart to the traffic on the section, and to the extra material placed over the wheel paths.

Again, the average compaction of the cores taken near centreline and the edge of pavement was lower than that in the wheel paths. However in this case, the compaction results from the cores near the edge of pavement included one high result of 99.7% (Appendix 2). The other two cores had compaction values of 98.0 and 98.3%. If the high value of 99.7% is ignored, the compaction along the edge of pavement would be 98.1%, a compaction lower than that found at centreline. This would be consistent with the other two test areas.

5.2.4 Overall Compaction Results

Compaction values found in the areas where the Dynapac paver was used were consistently higher than those in areas paved with the Cedar Rapids paver (refer to the average compaction of the cores taken in each area shown in Fig.10). Part of this increase may have been the result of fundamental differences between the two pavers.

It was obvious during the paving of the test areas that the Dynapac paver proceeded at a slower pace than the Cedar Rapids paver. This slower pace may have resulted in a mat more thoroughly compacted than that placed by the conventional paver. Also, the rollers may have spent more time compacting the pavement laid in the Dynapac area which could have led to an overall higher percent compaction in Test Areas 2 and 3.

Finally, different vibratory characteristics of the two screeds may have contributed to compaction differences.

Because of these variables, compaction results have been analyzed by test area, and only compared to the results from cores in other positions across the lane in that same test area. The comparison of results from cores taken from different test areas would not be reasonable.

5.3 Pavement Template Survey

A template survey was done before and after the new construction to monitor the change in the pavement cross section. The survey was done using a template rod. The rod, which is supported by a 50 mm block under each end, is laid horizontally across the pavement. The vertical distance between the rod and the pavement is measured at intervals of 0.3 m across the rod, and the pavement cross-fall is recorded. From this data, using the rod as a reference line, a cross section of the pavement can be plotted.

The cross section of the pavement was recorded at 25 m intervals. The data obtained from the survey, taken before and after the new construction, can be found in Appendix 3. This data has been adjusted for sag across the template rod.

Samples of the template survey data are graphically displayed in Appendix 3. Three graphs are supplied for each test area, at the stations where a line of core samples was located. Each graph contains a cross section of the original and the new pavement in the driving lane at that station. In Test Areas 1 and 2, where the top 40 mm of existing hot mix was milled off, the milled surface is shown. The location of the cores is represented by a broken line.

In general, the rutting present in Test Area 3 (pre-rehabilitation) was much less severe than that in Test Areas 1 and 2, as shown by the graphs. In most cases, the crowns over the wheel tracks were rolled flat by the rolling train.

The cross section of the pavement in the test areas will be monitored each year to record the extent of any pavement deformation. The resistance of the pavement in the test areas to wheel track rutting will be the best indication of the success or failure of the triple-jointed screed method.

5.4 Gyratory Testing Machine

Four samples of the hot mix placed in the test section were tested using the Gyratory Testing Machine (GTM). The GTM is used to evaluate the rutting potential of asphalt mixes. The data obtained from the GTM testing can be found in Appendix 4. For an explanation of the GTM parameters and their evaluation criteria, refer to "Evaluation of the Rutting Potential of Asphalt Mixes Using the Gyratory Testing Machine", by K. K. Tam (EM-78).

6.0 COST OF THE TEST SECTION

The bulk of the cost of the experimental section was the rental fee charged by Dynapac for the paver. Other costs were related to the time necessary for the paving crew to familiarize themselves with the new paver, and the time spent adjusting the height of the joints on the screed.

Once set up, no further complications were encountered using the Dynapac paver. However, because of the slower speed of the Dynapac paver, loss of production could take place.

7.0 CONCLUSIONS

1. The joint adjustment system on the triple-jointed screed is difficult to work with. As it is now, the trial and error method of screed adjustment is not conducive to frequent changes for different job situations.

2. Upon visual inspection, the mat laid by the Dynapac paver is acceptable.

3. The 7 mm crowns placed over the wheel paths by the triple-jointed screed were virtually rolled flat by the rolling train.

4. Placing the hot mix using the triple-jointed screed, set with crowns over the wheel paths, resulted in a pavement with lower compaction in the centre of the lane. The percent compaction in the wheel tracks was about 1% higher than the average compaction of the pavement placed with the triple-jointed screed.

5. The major cost of the test section was the machine rental fee. Other costs included compensation to the Contractor for time spent learning to operate the new machine.

6. Differences in the average percent compaction between test areas may have been partly due to fundamental differences between the European Dynapac and North American Cedar Rapids paver.

8.0 RECOMMENDATIONS

1. The performance of the test areas in the future should be monitored. A template survey of the section should be done each year to monitor the development of any pavement deformation.

2. If any further test areas are constructed with the Dynapac system, an area should be paved using the Dynapac paver with no crown set over the wheel paths. This area could then be compared to a similar area paved with the crowns, without introducing the other variables that arise from using two different pavers.

3. For a more versatile machine, the triple-jointed screed system should be modified so that crown adjustments can be made quickly and accurately (a necessity if further testing is to be considered).

APPENDIX 1 - PLATE SAMPLE RESULTS

SECTION		STATION	OFFSET	% VOIDS	FLOW	STABILITY (N)	% VMA	% A.C.	RET 4.75	PASS 75
TEST AREA 1		15+522	1.8	4.4	9.8	14078	16.6	5.21	48.2	3.8
		15+641	2.6	4.1	9.9	13225	16.2	5.10	50.0	3.8
		15+795	1.0	4.1	10.7	14118	16.3	5.28	50.3	3.9
AVERAGE				4.2	10.1	13807	16.4	5.20	49.5	3.8
TEST AREA 2		16+042	1.0	4.8	9.7	11518	17.4	5.53	47.1	3.4
		16+155	1.0	4.0	11.0	14596	16.1	5.04	51.3	3.1
		16+299	2.1	4.0	10.1	13983	16.0	5.15	50.0	3.6
AVERAGE				4.3	10.3	13366	16.5	5.24	49.5	3.4
TEST AREA 3		16+506	1.3	4.4	10.8	16271	16.6	5.04	49.4	3.1
		16+606	1.1	4.4	10.7	12952	16.7	5.30	51.3	3.6
		16+731	1.8	3.9	9.7	11810	16.1	5.08	48.8	3.9
AVERAGE				4.2	10.4	13678	16.5	5.14	49.8	3.5
OVERALL AVER				4.2	10.3	13617	16.4	5.2	49.6	3.6
MIX DESIGN				3.5	10.2	11400	16.9	5.4	51.5	2.1

Properties of Plate Samples from Test Areas

SECTION	STATION	OFFSET	% RETAINED ON SIEVE								
			9.5 mm	6.7 mm	4.75 mm	2.36 mm	1.18 mm	600 µm	300 µm	150 µm	75 µm
TEST AREA 1	15+522	1.8	20	43	50	55	58	65	86	94	96
	15+641	2.6	21	42	50	55	58	65	86	94	96
	15+795	1.0	18	29	47	52	56	63	87	94	97
TEST AREA 2	16+042	1.0	20	43	50	55	59	67	87	94	96
	16+155	1.0	23	43	49	55	59	67	88	95	97
	16+299	2.1	17	39	48	54	57	65	86	94	96
TEST AREA 3	16+506	1.3	25	45	51	56	59	67	88	95	97
	16+606	1.1	22	45	51	56	60	68	88	94	96
	16+731	1.8	20	42	49	54	58	67	87	94	96

Sieve Analysis Results from Plate Samples

APPENDIX 2 - CORE RESULTS

Core Sample Locations

CORE #	STATION	O/S FROM CENTRELINE OF EASTBOUND LANES (m)
1	15+555	0.31
2	15+552	0.91
3	15+554	1.83
4	15+553	2.74
5	15+555	3.35
6	15+729	0.31
7	15+726	0.91
8	15+728	1.83
9	15+727	2.74
10	15+729	3.35
11	15+858	0.31
12	15+855	0.91
13	15+857	1.83
14	15+856	2.74
15	15+858	3.35
16	16+086	0.31
17	16+083	0.91
18	16+085	1.83
19	16+084	2.74
20	16+086	3.35
21	16+186	0.31
22	16+183	0.91
23	16+185	1.83
24	16+184	2.74
25	16+186	3.35
26	16+342	0.31
27	16+339	0.91
28	16+341	1.83
29	16+340	2.74
30	16+342	3.35
31	16+541	0.31
32	16+538	0.91
33	16+540	1.83
34	16+539	2.74
35	16+541	3.35
36	16+655	0.31
37	16+652	0.91
38	16+654	1.83
39	16+653	2.74
40	16+655	3.35
41	16+909	0.31
42	16+906	0.91
43	16+908	1.83
44	16+907	2.74
45	16+909	3.35

CORE RESULTS BY O/S & AREA

SECTION	OFFSET	CORE	THICK	AV THICK	% COMP	AV COMP
CONVENT	0.31 m	1	56	50	97.9	97.8
PAVER		6	44		97.4	
		11	50		98.0	
	0.91 m	2	54	50	97.9	98.8
		7	44		99.6	
		12	51		98.9	
	1.83 m	3	52	48	97.9	98.3
		8	44		98.4	
		13	48		98.7	
	2.74 m	4	49	46	98.9	98.9
		9	42		98.8	
		14	46		98.9	
	3.35 m	5	-	41	96.5	97.6
		10	-		97.2	
		15	41		99.2	
DYNAPAC	0.31 m	16	54	53	99.5	99.2
PAVER		21	58		98.9	
		26	46		99.1	
	0.91 m	17	56	55	99.9	99.6
		22	61		99.8	
		27	49		99.2	
	1.83 m	18	51	50	96.8	96.9
		23	54		96.8	
		28	45		97.2	
	2.74 m	19	46	47	100.2	100.0
		24	50		100.2	
		29	45		99.7	
	3.35 m	20	37	37	98.1	98.4
		25	38		98.4	
		30	36		98.7	

CORE RESULTS BY O/S & AREA

SECTION	OFFSET	CORE	THICK	AV THICK	% COMP	AV COMP
DYNAPAC	0.31 m	31	45	46	97.6	98.3
OVERLAY		36	43		98.9	
		41	49		98.4	
	0.91 m	32	50	52	99.8	100.1
		37	50		100.0	
		42	55		100.4	
	1.83 m	33	44	45	98.3	97.8
		38	38		96.0	
		43	53		99.2	
	2.74 m	34	47	46	99.9	100.1
		39	44		100.3	
		44	46		100.1	
	3.35 m	35	43	41	98.0	98.9
		40	34			
		45	46		99.7	
OVERALL						
AVERAGE			47		98.7	

APPENDIX 3 - TEMPLATE SURVEY DATA

ADJUSTED														XFALL
O/S (m)	0	.31	.61	.91	1.22	1.52	1.83	2.13	2.44	2.94	3.05	3.35	3.66	%
STATION														
15+450	5.1	4.9	5.1	5.5	5.6	4.6	4.1	3.7	3.5	4.0	3.9	4.0	5.1	4.5
	5.1	5.0	4.9	5.3	5.7	4.8	4.1	3.9	3.7	4.2	4.0	4.3	5.1	4.0
15+500	5.1	5.2	5.2	5.4	5.8	5.0	4.3	4.0	3.7	4.2	4.1	4.3	5.1	4.0
	5.1	5.2	5.4	6.1	6.3	5.0	4.3	4.5	4.6	5.1	4.4	4.7	5.1	2.0
	5.1	5.2	5.3	5.7	6.6	5.0	4.3	5.0	4.9	5.6	5.4	5.0	5.1	1.5
	5.1	5.3	5.6	6.2	6.4	4.5	4.7	5.0	5.5	5.8	5.2	4.7	5.1	1.5
15+600	5.1	5.3	5.8	6.4	6.2	4.4	4.6	4.7	5.5	6.0	5.7	3.9	5.1	1.5
	5.1	5.2	5.7	6.0	6.0	4.1	4.6	4.8	4.8	5.4	5.0	4.5	5.1	2.0
	5.1	5.2	6.0	6.4	6.0	3.7	4.7	5.0	5.3	5.5	5.1	4.6	5.1	1.5
	5.1	5.3	5.8	6.2	5.9	4.2	4.7	4.9	5.6	5.8	5.1	4.7	5.1	1.5
15+700	5.1	5.2	6.0	6.7	6.4	3.6	4.5	4.7	5.6	6.3	5.7	3.3	5.1	1.5
	5.1	5.1	5.3	5.9	6.7	4.1	4.6	4.8	4.7	5.9	5.6	4.6	5.1	1.5
	5.1	5.0	5.5	6.2	6.3	3.7	4.3	4.5	5.2	5.6	5.3	4.6	5.1	2.0
	5.1	4.7	4.8	5.5	-	5.1	3.4	4.3	4.5	5.6	5.8	5.2	5.1	1.5
15+800	5.1	4.9	4.8	5.7	6.0	4.0	3.4	4.4	4.4	5.4	5.2	4.5	5.1	1.5
	5.1	5.1	5.2	6.6	6.7	4.7	4.3	4.3	4.9	6.4	6.2	3.9	5.1	2.0
	5.1	5.1	5.3	6.6	6.5	3.6	4.6	4.7	4.7	6.1	5.7	4.3	5.1	2.0
	5.1	5.0	5.1	6.9	6.9	3.5	3.7	4.3	4.6	6.4	6.0	3.0	5.1	2.0
15+900	5.1	5.2	5.2	6.5	6.8	3.5	3.7	4.2	4.8	6.3	5.8	4.4	5.1	1.5
	5.1	5.2	5.3	6.8	6.8	3.4	4.0	4.3	4.8	6.4	5.8	3.5	5.1	1.5
	5.1	5.2	5.5	6.2	6.7	3.7	4.2	4.3	5.1	6.1	5.6	4.8	5.1	2.0
	5.1	5.1	5.2	6.5	6.5	3.9	4.2	4.3	4.9	6.3	-	4.3	5.1	1.5
16+000	5.1	4.9	5.3	6.7	6.9	3.6	3.9	3.8	5.1	6.7	-	3.9	5.1	1.5
	5.1	5.1	5.5	6.4	7.0	3.8	4.3	4.0	5.1	6.2	5.7	4.4	5.1	1.5
	5.1	5.3	5.6	6.5	6.8	3.6	4.7	4.7	5.1	6.4	5.8	4.6	5.1	2.0

*offset from centreline of eastbound lanes
**measurements from template rod to pavement are recorded in cm

BEFOFE CONSTRUCTION X SECTION

O/S (m)	0	.31	.61	.91	1.22	1.52	1.83	2.13	2.44	2.94	3.05	3.35	3.66	XFALL
STATION														%
16+075	5.1	5.1	6.0	6.4	6.7	4.1	4.7	4.6	5.5	5.8	4.9	4.6	5.1	2.0
16+100	5.1	5.0	5.1	6.4	6.8	5.8	3.6	4.8	4.7	5.8	5.7	5.1	5.1	2.5
	5.1	4.9	4.6	6.4	6.9	5.6	3.2	4.4	4.4	5.8	5.7	5.1	5.1	2.5
16+150	5.1	4.9	4.8	5.9	6.8	6.2	3.5	4.1	4.4	5.1	5.3	5.0	5.1	3.0
	5.1	4.9	5.2	6.7	6.9	3.9	3.3	4.3	3.9	5.4	5.0	4.5	5.1	3.0
16+200	5.1	4.8	5.1	6.7	6.8	3.8	3.3	3.8	4.0	5.5	4.9	4.5	5.1	3.0
	5.1	4.8	5.3	6.7	7.0	3.2	3.1	4.0	4.3	5.8	5.2	3.3	5.1	3.0
	5.1	4.8	5.4	6.9	6.8	3.4	3.2	3.8	4.4	5.8	5.2	3.2	5.1	3.0
	5.1	5.1	5.0	5.7	7.1	6.7	3.7	4.2	4.2	5.4	6.2	5.6	5.1	3.0
16+300	5.1	5.0	4.9	6.4	6.8	5.6	3.3	4.1	4.1	5.0	4.7	4.0	5.1	3.5
	5.1	5.0	5.0	5.7	6.3	5.6	3.3	4.3	4.0	4.9	5.1	4.7	5.1	3.5
	5.1	5.0	5.0	5.6	5.7	4.4	3.2	3.6	3.4	4.2	3.9	4.0	5.1	3.0
	5.1	4.9	5.0	5.6	5.8	5.0	3.9	4.2	5.2	5.0	4.7	4.5	5.1	3.0
16+400	5.1	4.9	5.1	5.6	5.9	4.9	4.5	4.3	4.0	5.1	4.9	4.2	5.1	3.0
	5.1	4.9	5.0	5.6	5.6	4.6	4.3	4.2	4.0	5.1	4.5	4.5	5.1	2.0
	5.1	5.1	5.0	5.2	5.4	5.0	4.0	3.5	3.6	4.7	4.5	4.5	5.1	2.0
	5.1	5.0	5.1	5.2	5.9	4.5	4.6	4.5	4.4	5.0	4.7	4.4	5.1	2.5
16+500	5.1	5.1	5.2	5.2	5.6	4.3	4.2	4.2	4.4	4.9	4.6	4.7	5.1	2.5
	5.1	5.2	5.6	5.2	5.9	4.6	4.6	4.5	5.5	5.6	4.9	5.0	5.1	2.5
	5.1	5.2	5.9	5.2	5.9	4.6	4.7	5.2	5.6	5.7	4.8	5.1	5.1	2.5
	5.1	5.3	5.5	5.2	5.9	4.7	4.6	5.0	5.3	5.5	4.9	5.0	5.1	2.5
16+600	5.1	5.2	5.2	5.2	5.8	4.2	4.3	4.8	4.9	5.5	5.2	5.0	5.1	2.5
	5.1	5.1	5.6	5.3	5.5	4.1	4.4	4.6	4.9	5.2	4.2	4.3	5.1	2.0
	5.1	5.3	5.6	5.9	5.6	4.4	4.7	4.8	4.8	4.9	4.4	4.5	5.1	2.5
	5.1	5.3	5.2	5.8	5.6	4.9	4.2	4.8	4.6	5.4	5.2	4.9	5.1	2.5
16+700	5.1	5.3	5.3	5.8	6.1	4.5	4.2	4.4	4.7	5.4	5.2	4.7	5.1	3.0

*offset from centreline of eastbound lanes
**measurements from template rod to pavement are recorded in cm

BEFOFE CONSTRUCTION X SECTION

O/S (m)	0	.31	.61	.91	1.22	1.52	1.83	2.13	2.44	2.94	3.05	3.35	3.66	XFALL
STATION														%
16+725	5.1	5.3	5.1	5.9	6.1	4.5	4.3	4.6	4.6	5.6	5.2	4.7	5.1	2.5
	5.1	5.1	5.1	5.9	6.3	4.4	4.2	4.6	4.6	5.9	5.5	4.7	5.1	2.0
	5.1	5.4	5.5	5.9	6.6	4.6	4.6	4.7	4.9	5.6	5.5	4.8	5.1	2.5
16+800	5.1	5.3	5.4	5.9	6.5	4.7	4.8	4.8	5.1	5.9	5.7	5.1	5.1	2.5
	5.1	5.3	5.4	6.1	6.5	4.3	4.7	4.9	5.1	5.7	5.3	5.1	5.1	2.5
	5.1	5.3	5.4	6.2	6.3	4.6	4.5	4.8	5.1	5.8	5.4	5.1	5.1	2.5
	5.1	5.3	5.5	5.9	6.1	4.6	4.4	4.9	5.2	5.4	4.8	4.7	5.1	2.5
16+900	5.1	5.3	5.4	5.9	6.3	4.7	4.4	4.9	5.1	6.0	5.7	4.7	5.1	2.5
	5.1	5.5	5.5	5.9	6.2	5.2	4.8	5.1	5.0	5.7	5.3	4.9	5.1	2.0
16+950	5.1	5.1	5.3	5.4	6.3	5.7	4.4	4.1	4.5	5.4	5.5	5.2	5.1	2.0

*offset from centreline of eastbound lanes
**measurements from template rod to pavement are recorded in cm

BEFOFE CONSTRUCTION X SECTION

ADJUSTED														XFALL
O/S (m)	0	.31	.61	.91	1.22	1.52	1.83	2.13	2.44	2.94	3.05	3.35	3.66	%
STATION														
15+450	5.1	5.1	5.3	5.2	5.2	5.0	4.6	4.6	4.4	4.7	4.6	4.8	5.1	4.5
	5.1	5.2	4.9	4.9	4.9	4.7	4.4	4.3	4.1	4.3	4.2	4.6	5.1	4.5
15+500	5.1	5.2	4.9	4.9	5.0	4.7	4.4	4.3	4.1	4.2	4.2	4.6	5.1	4.0
	5.1	5.1	5.0	5.0	5.1	4.8	5.1	4.4	4.2	4.4	4.3	4.6	5.1	2.5
	5.1	5.3	5.1	5.0	5.3	5.1	4.9	4.8	4.5	4.7	4.6	5.0	5.1	1.5
	5.1	5.2	5.1	5.1	5.2	4.9	4.9	4.8	4.6	4.6	4.5	4.6	5.1	2.0
15+600	5.1	5.3	5.1	5.1	5.3	4.9	4.8	4.8	4.6	4.5	4.5	4.6	5.1	1.5
	5.1	5.2	5.1	5.2	5.3	5.1	4.9	4.8	4.6	4.5	4.5	4.6	5.1	2.0
	5.1	5.2	5.1	5.0	5.2	4.9	4.8	4.7	4.5	4.6	4.6	4.8	5.1	1.5
	5.1	5.2	5.0	4.9	5.1	4.7	4.6	4.5	4.4	4.4	4.4	4.7	5.1	2.0
15+700	5.1	5.1	5.1	5.1	5.0	4.6	4.5	4.4	4.2	4.4	4.2	4.5	5.1	2.0
	5.1	5.2	5.0	5.0	5.0	4.7	4.5	4.4	4.1	4.2	4.1	4.6	5.1	2.0
	5.1	5.2	5.1	5.0	5.0	4.8	4.5	4.6	4.4	4.6	4.6	4.7	5.1	2.0
	5.1	5.1	5.1	5.0	5.2	5.0	4.9	4.8	4.6	4.7	4.7	5.0	5.1	1.5
15+800	5.1	5.2	5.0	5.0	5.3	5.0	4.9	4.8	4.6	4.5	4.5	4.6	5.1	2.0
	5.1	5.2	5.1	5.1	5.4	5.2	5.0	5.0	4.8	4.9	4.9	5.0	5.1	2.0
	5.1	5.3	5.1	5.1	5.4	5.1	5.0	4.9	4.6	4.8	4.8	4.9	5.1	1.5
	5.1	5.1	5.1	5.1	5.3	5.1	5.0	4.9	4.6	4.8	4.8	5.0	5.1	1.5
15+900	5.1	5.1	5.1	5.1	5.2	4.9	4.8	4.7	4.3	4.5	4.4	4.5	5.1	1.5
	5.1	5.3	5.1	5.0	5.2	4.9	4.8	4.7	4.4	4.5	4.5	4.7	5.1	1.5
	5.1	5.2	5.1	5.2	5.2	4.9	4.9	4.7	4.4	4.6	4.6	4.7	5.1	1.5
	5.1	5.3	5.1	5.2	5.0	5.0	5.0	4.7	4.3	4.4	4.3	4.6	5.1	1.5
16+000	5.1	5.1	4.9	4.8	5.0	4.9	4.9	4.6	4.2	4.3	4.2	4.6	5.1	1.5
	5.1	5.2	5.0	4.8	5.0	4.9	4.8	4.6	4.2	4.1	4.1	4.3	5.1	2.0
	5.1	5.0	4.6	4.4	4.3	4.2	4.1	3.7	3.2	3.3	3.6	4.2	5.1	3.0

*offset from centreline of eastbound lanes
**measurements from template rod to pavement are recorded in cm

AFTER CONSTRUCTION X SECTION

O/S (m)	0	.31	.61	.91	1.22	1.52	1.83	2.13	2.44	2.94	3.05	3.35	3.66	XFALL
STATION														%
16+075	5.1	4.9	4.6	4.3	4.3	4.5	4.3	4.0	3.7	3.6	3.8	4.5	5.1	3.5
16+100	5.1	4.9	4.6	4.3	4.3	4.1	4.1	4.0	3.4	3.6	3.8	4.5	5.1	3.0
	5.1	5.0	4.6	4.6	4.6	4.5	4.5	4.0	3.9	3.8	3.8	4.4	5.1	3.0
	5.1	5.1	4.7	4.8	4.8	4.6	4.6	4.0	3.6	3.6	3.6	4.2	5.1	3.0
	5.1	5.1	4.6	4.8	4.7	4.5	4.4	4.0	3.6	3.8	3.8	4.5	5.1	3.5
16+200	5.1	5.1	9.5	4.9	5.0	4.6	4.4	4.0	3.6	3.9	4.1	4.4	5.1	3.0
	5.1	5.2	4.6	4.7	4.9	4.8	4.8	4.6	4.2	3.9	4.3	4.6	5.1	3.0
	5.1	4.9	4.5	4.6	4.5	4.3	4.1	3.8	3.4	3.6	3.6	4.3	5.1	4.0
	5.1	4.9	4.6	4.5	4.6	4.4	4.2	3.8	3.4	3.3	3.4	4.0	5.1	4.0
16+300	5.1	5.0	4.5	4.4	4.4	4.2	4.2	3.8	3.3	3.4	3.4	4.1	5.1	3.5
	5.1	5.0	4.5	4.6	4.5	4.3	4.2	3.8	3.3	3.5	3.5	4.1	5.1	3.5
	5.1	4.9	4.8	4.7	4.7	4.2	4.0	3.6	3.2	3.3	3.3	4.1	5.1	3.5
	5.1	5.0	4.7	4.7	4.8	4.5	4.4	4.0	3.6	3.9	4.1	4.2	5.1	3.0
16+400	5.1	5.0	4.6	4.8	4.8	4.3	4.3	3.8	3.5	3.6	3.7	4.1	5.1	3.5
	5.1	4.9	4.5	4.5	4.8	4.5	4.3	3.6	3.3	3.4	3.7	4.3	5.1	3.5
	5.1	4.7	4.2	4.0	3.9	3.5	3.0	2.7	2.5	2.9	3.4	4.6	5.1	3.0
	5.1	4.9	4.4	4.4	4.4	4.1	4.1	3.8	3.7	4.2	4.5	5.0	5.1	3.5
16+500	5.1	4.8	4.4	4.5	4.3	4.2	4.1	3.9	3.6	4.2	4.4	4.9	5.1	2.0
	5.1	5.0	4.4	4.3	4.3	4.1	4.2	3.9	3.6	3.9	4.3	4.9	5.1	2.5
	5.1	4.9	4.5	4.3	4.4	4.2	4.4	4.0	3.8	4.0	4.3	4.8	5.1	2.5
	5.1	4.9	4.5	4.5	4.4	4.2	4.3	4.0	3.8	4.2	4.6	4.9	5.1	2.5
16+600	5.1	4.9	4.4	4.4	4.4	4.2	4.4	4.2	3.8	4.1	4.3	4.9	5.1	2.5
	5.1	4.9	4.5	4.5	4.5	4.3	4.5	4.1	3.8	4.0	4.3	4.7	5.1	2.5
	5.1	5.0	4.5	4.4	4.5	4.2	4.4	4.2	3.8	3.9	4.4	4.9	5.1	2.5
	5.1	4.8	4.4	4.4	4.5	4.3	4.3	3.8	3.6	4.0	4.4	5.0	5.1	2.5
16+700	5.1	4.9	4.4	4.3	4.3	4.1	4.3	3.8	3.6	3.8	4.1	4.9	5.1	2.5

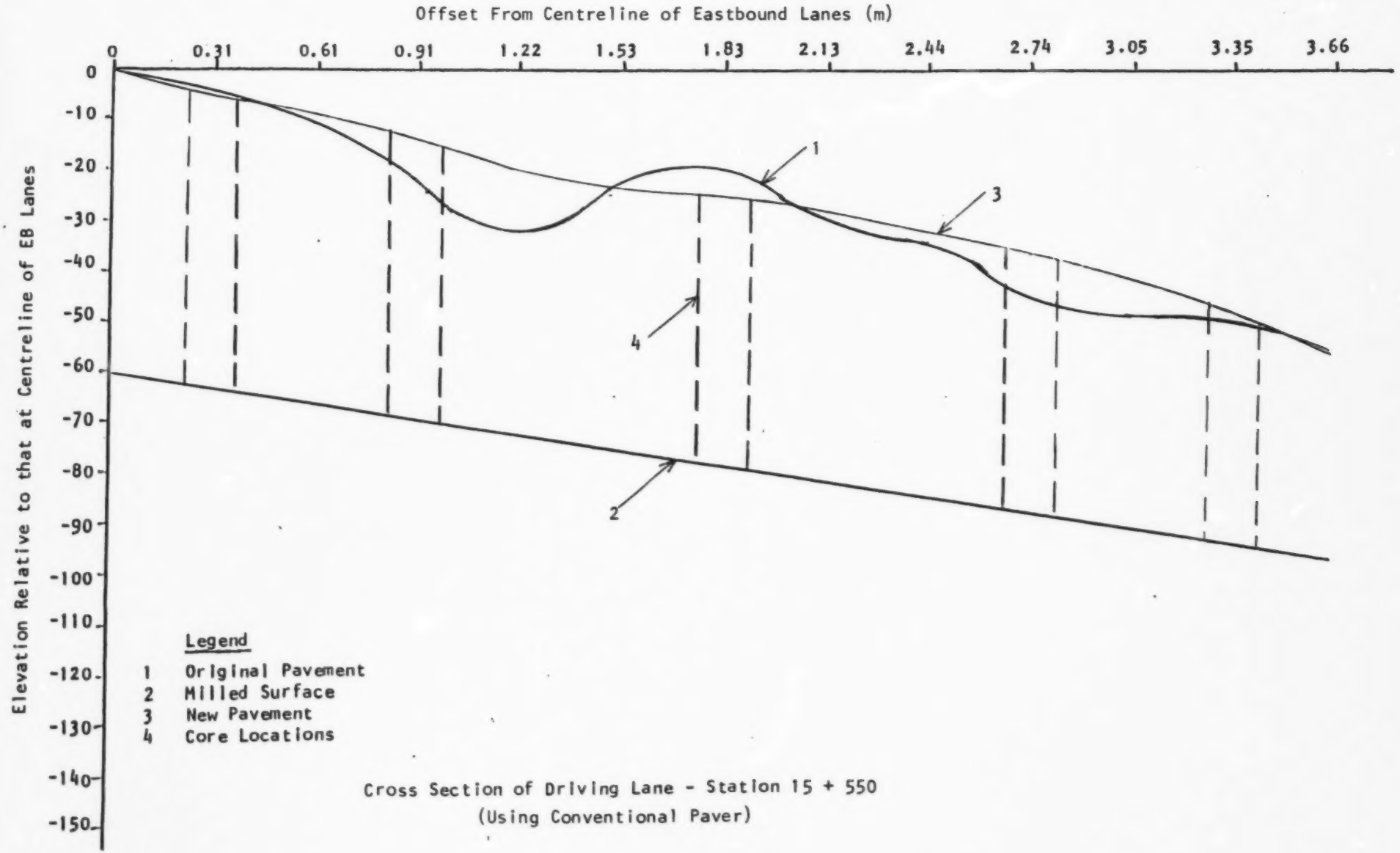
*offset from centreline of eastbound lanes
**measurements from template rod to pavement are recorded in cm

AFTER CONSTRUCTION X SECTION

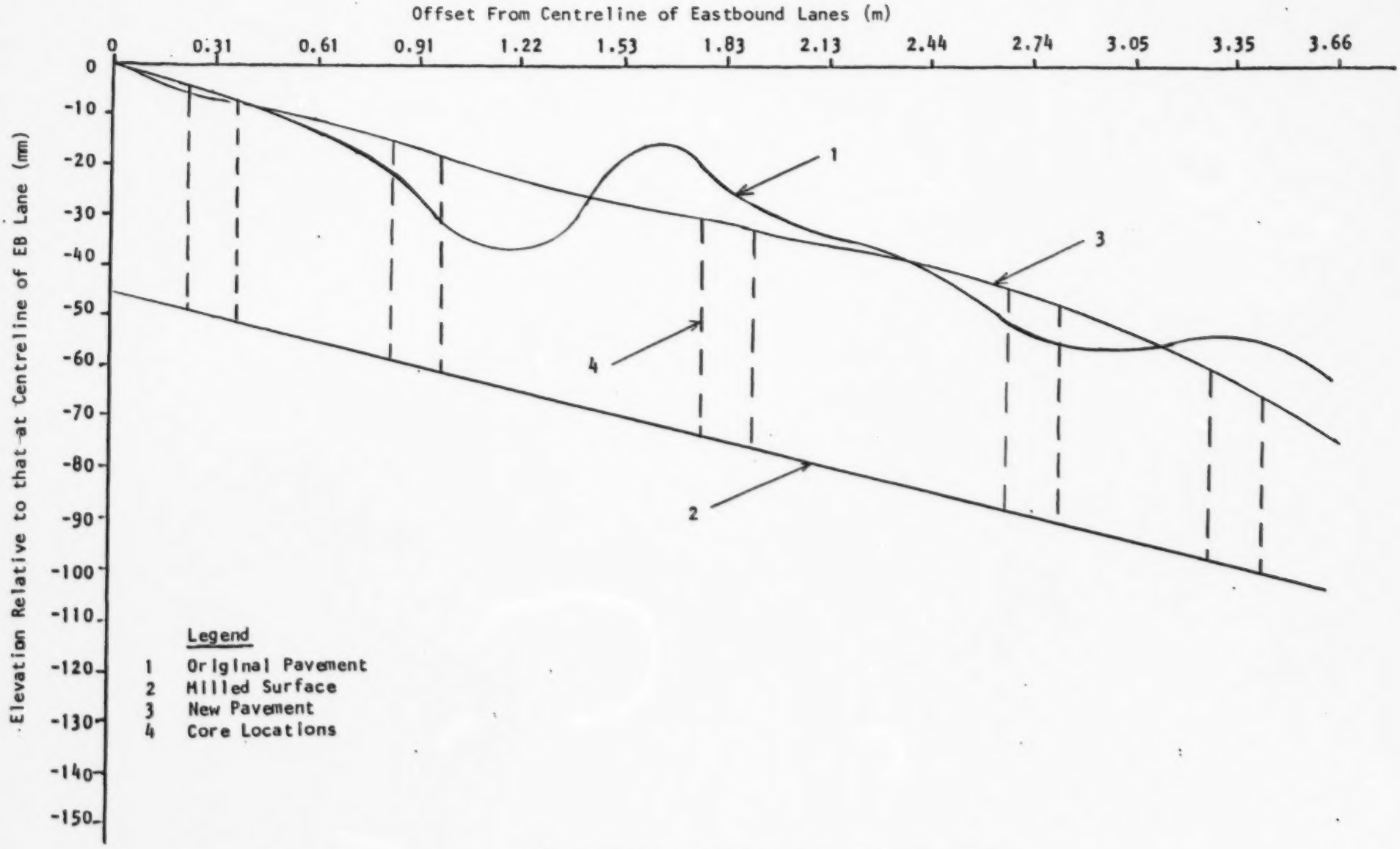
	0	.31	.61	.91	1.22	1.52	1.83	2.13	2.44	2.94	3.05	3.35	3.66	XFALL
STATION														%
16+725	5.1	4.8	4.3	4.4	4.4	4.2	4.1	3.9	3.6	3.9	4.4	5.0	5.1	2.0
	5.1	5.0	4.3	4.3	4.4	4.1	4.1	3.8	3.5	3.9	4.4	4.9	5.1	2.0
	5.1	4.8	4.1	4.1	4.4	4.1	4.1	3.8	3.6	3.8	4.3	4.8	5.1	2.5
16+800	5.1	5.0	4.4	4.3	4.3	4.1	4.2	3.8	3.6	3.9	4.2	4.8	5.1	2.5
	5.1	4.9	4.5	4.3	4.3	3.8	3.9	3.8	3.6	3.9	4.0	4.7	5.1	2.5
	5.1	4.8	4.3	4.4	4.4	4.1	4.2	3.8	3.5	3.9	4.0	4.6	5.1	2.0
	5.1	5.0	4.3	4.4	4.5	4.3	4.1	3.8	3.5	3.9	4.2	4.6	5.1	2.5
16+900	5.1	4.8	4.2	4.3	4.3	4.1	4.1	3.8	3.5	3.9	4.2	4.6	5.1	2.5
	5.1	4.9	4.3	4.1	4.3	3.9	3.8	3.8	3.5	3.8	4.3	4.7	5.1	2.5
16+950	5.1	4.9	4.3	4.5	4.7	4.1	4.2	3.8	3.6	3.9	4.3	4.7	5.1	2.5

*offset from centreline of eastbound lanes
**measurements from template rod to pavement are recorded in cm

AFTER CONSTRUCTION X SECTION

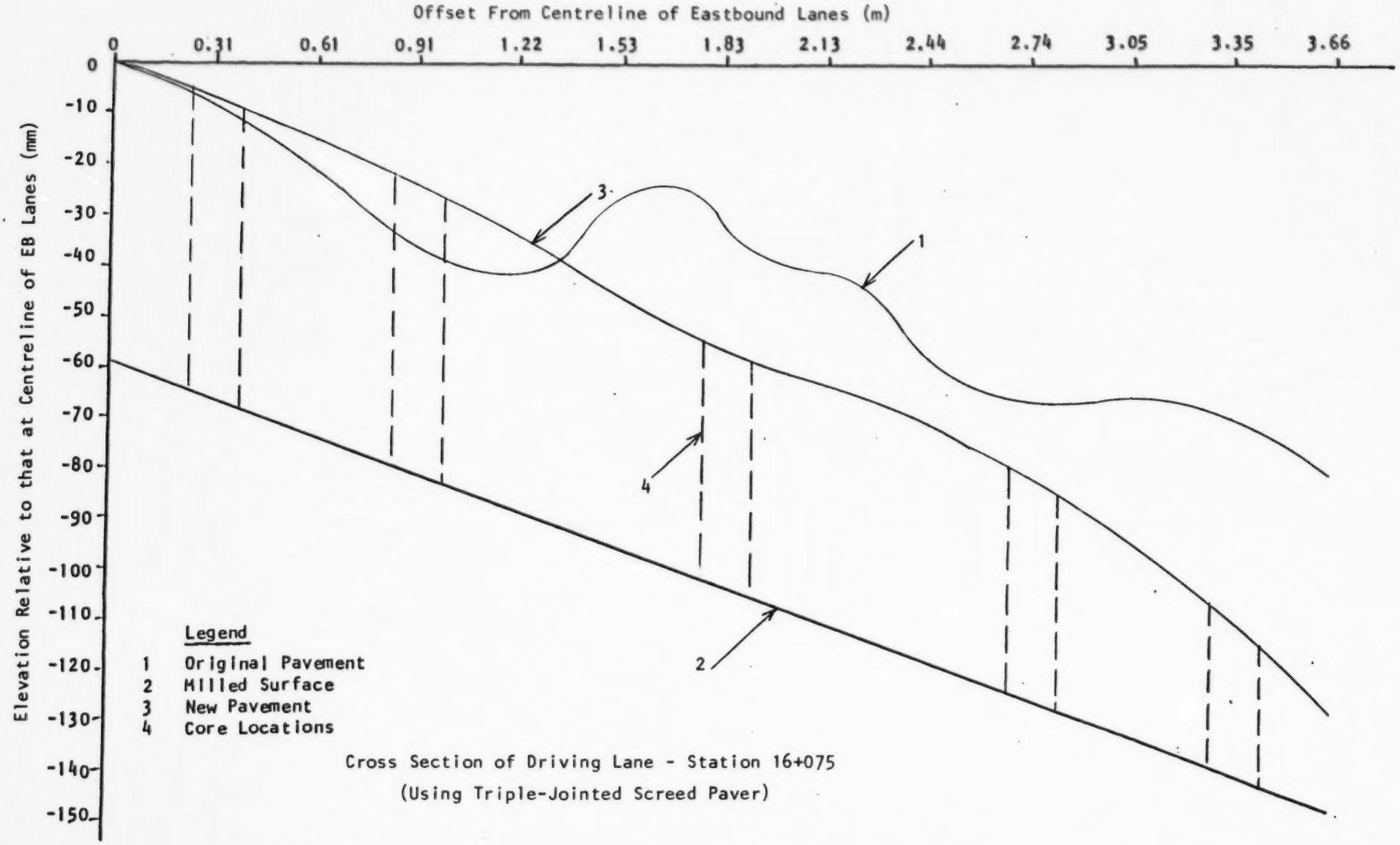


Cross Section of Driving Lane - Station 15 + 550
(Using Conventional Paver)



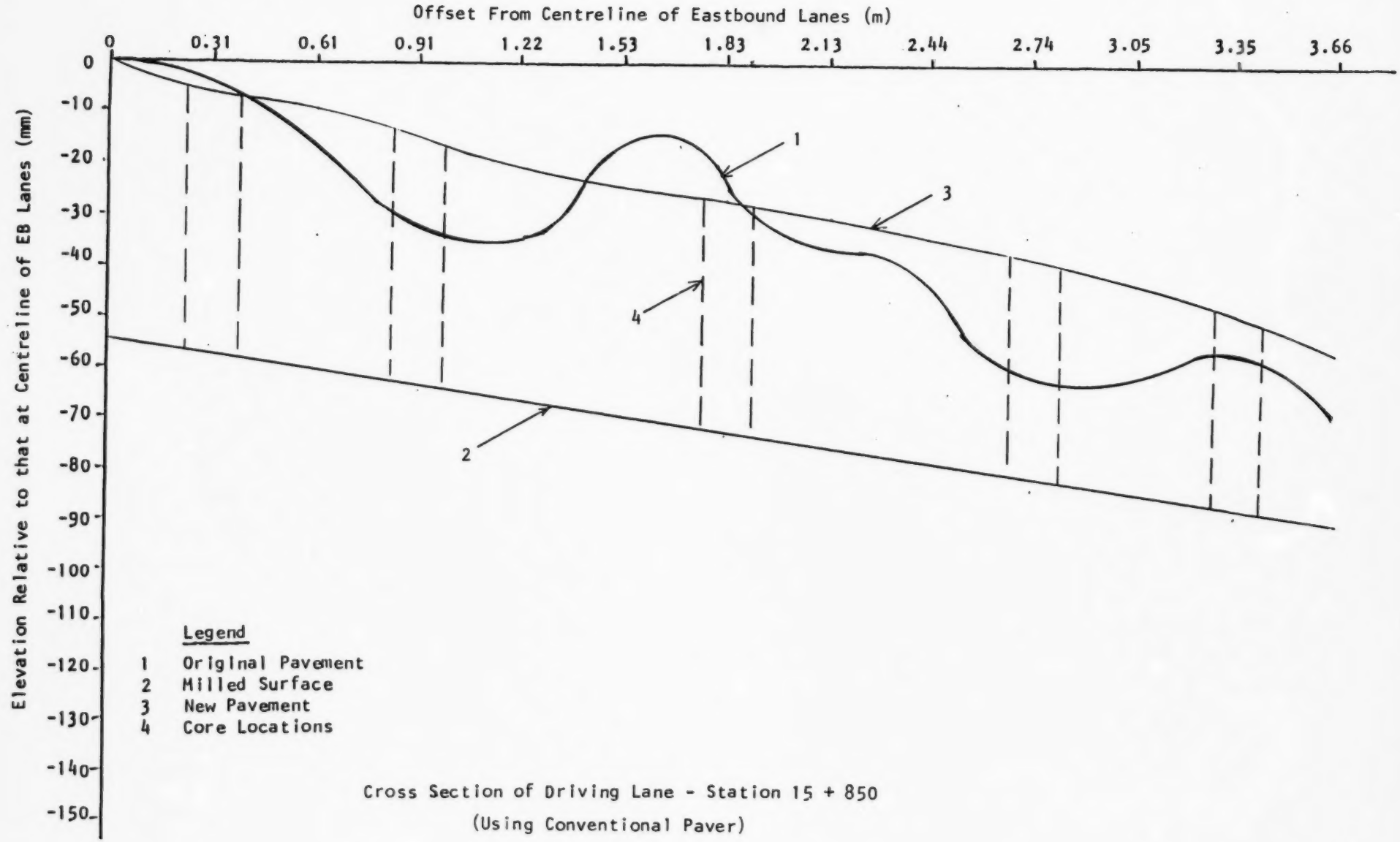
Cross Section of Driving Lane - Station 15+725

(Using Conventional Paver)



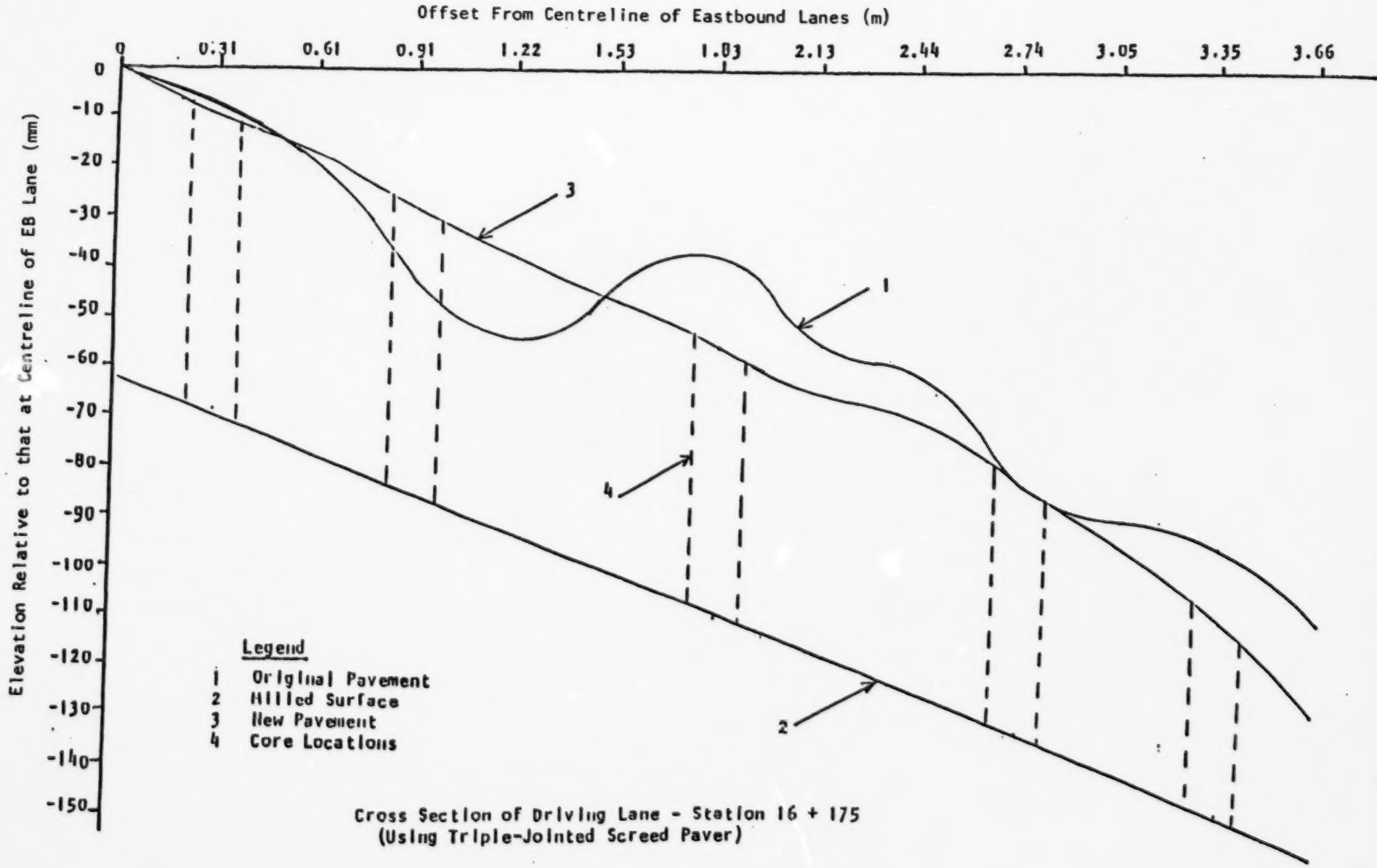
Cross Section of Driving Lane - Station 16+075

(Using Triple-Jointed Screed Paver)

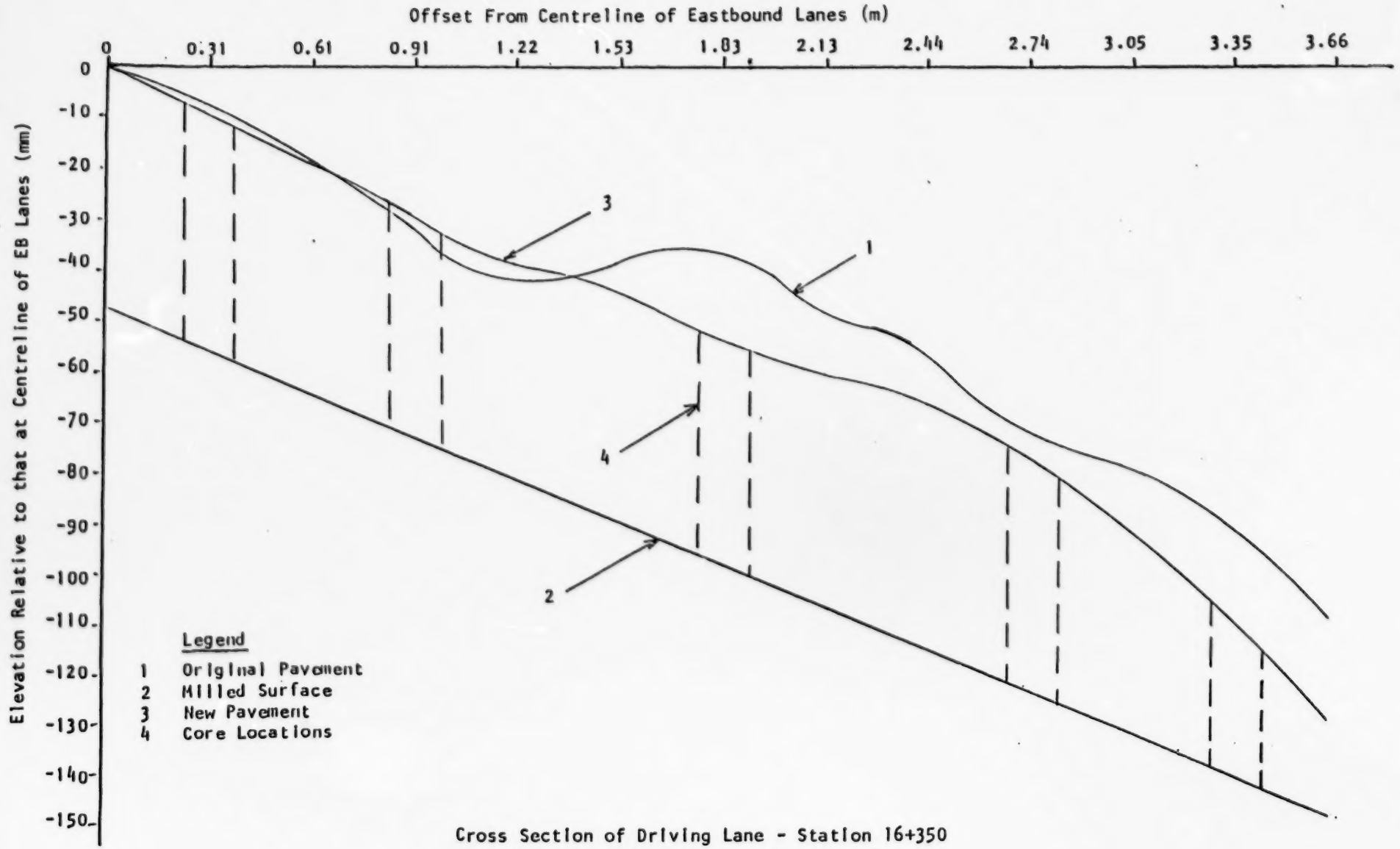


Cross Section of Driving Lane - Station 15 + 850

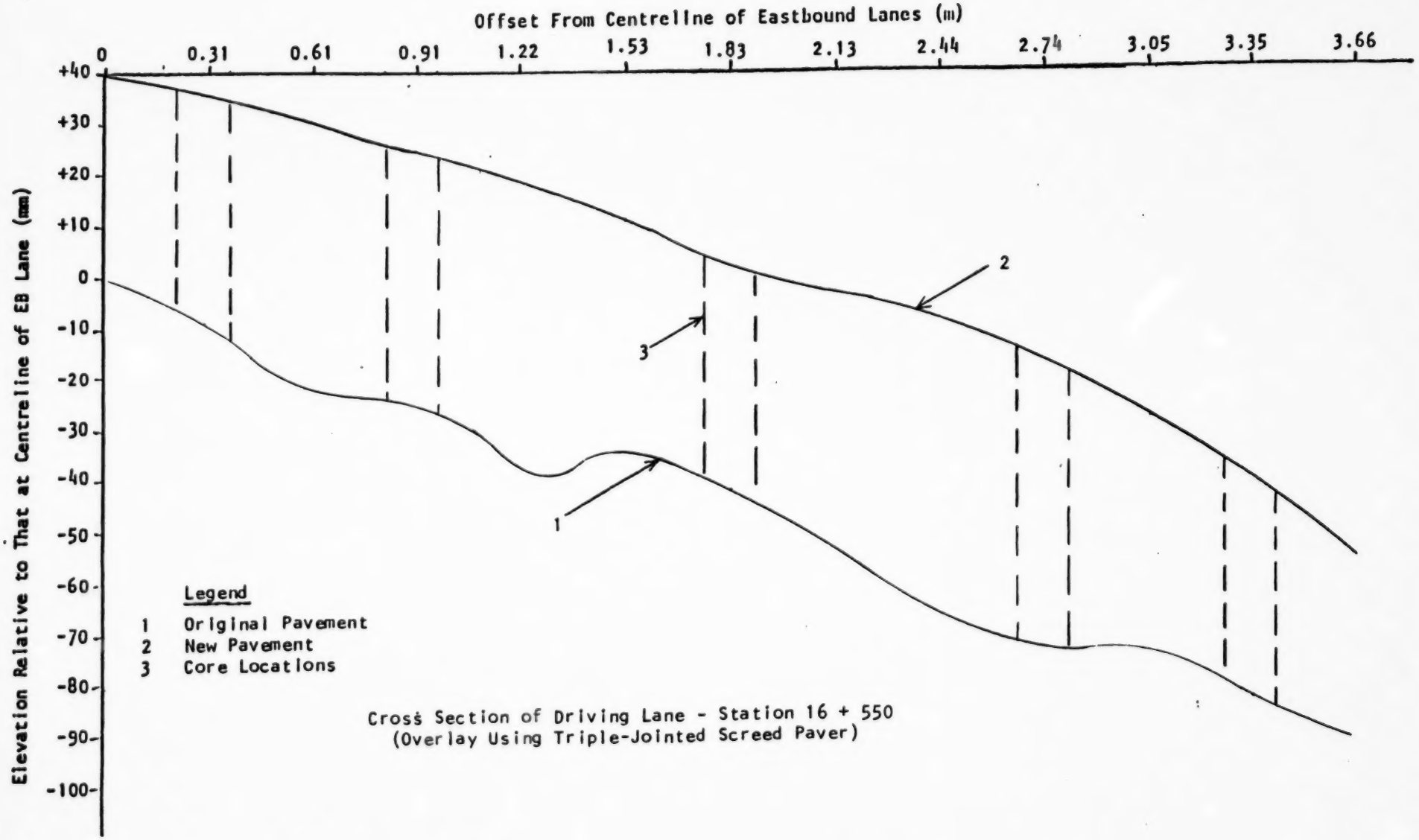
(Using Conventional Paver)



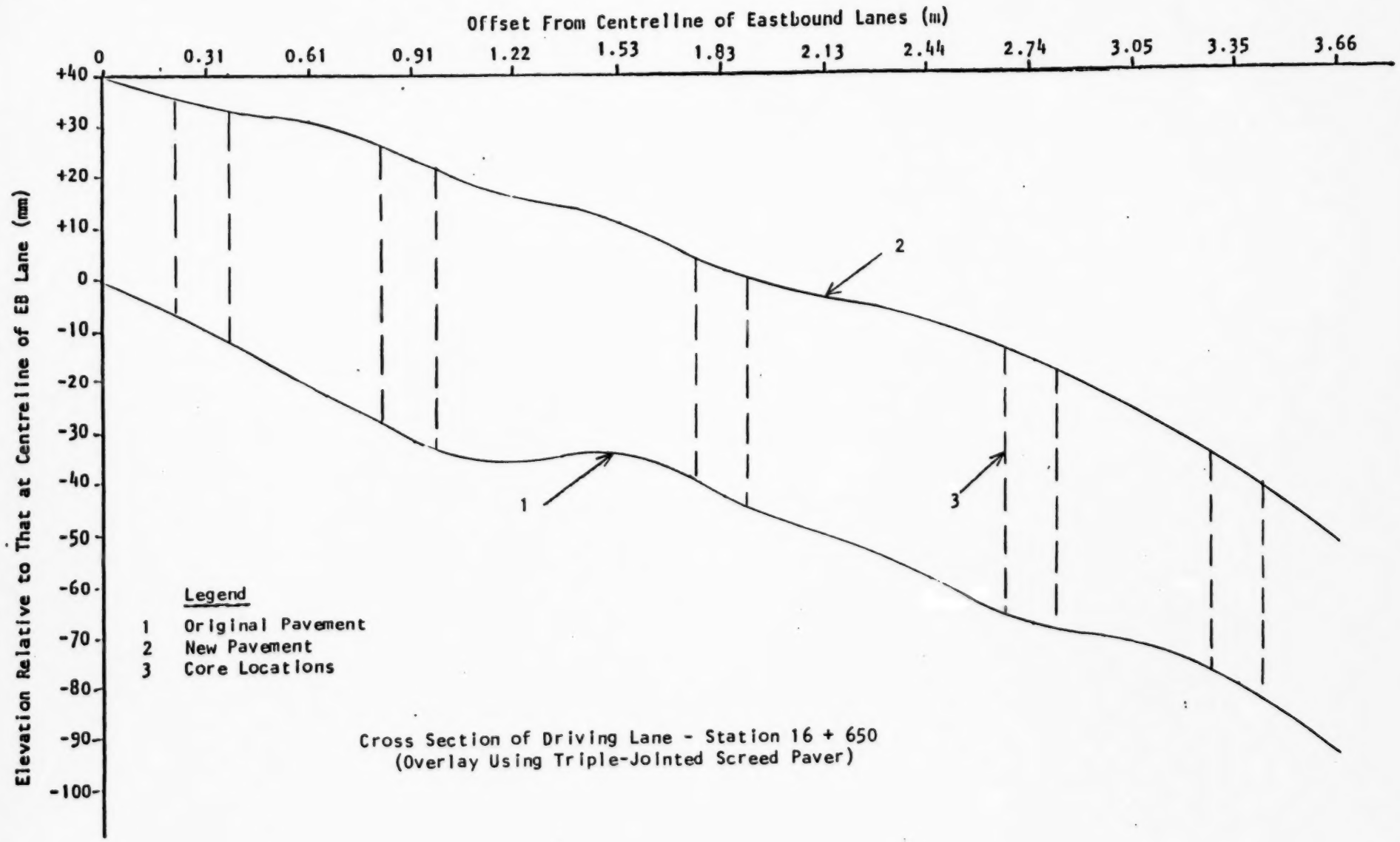
Cross Section of Driving Lane - Station 16 + 175
(Using Triple-Jointed Screed Paver)



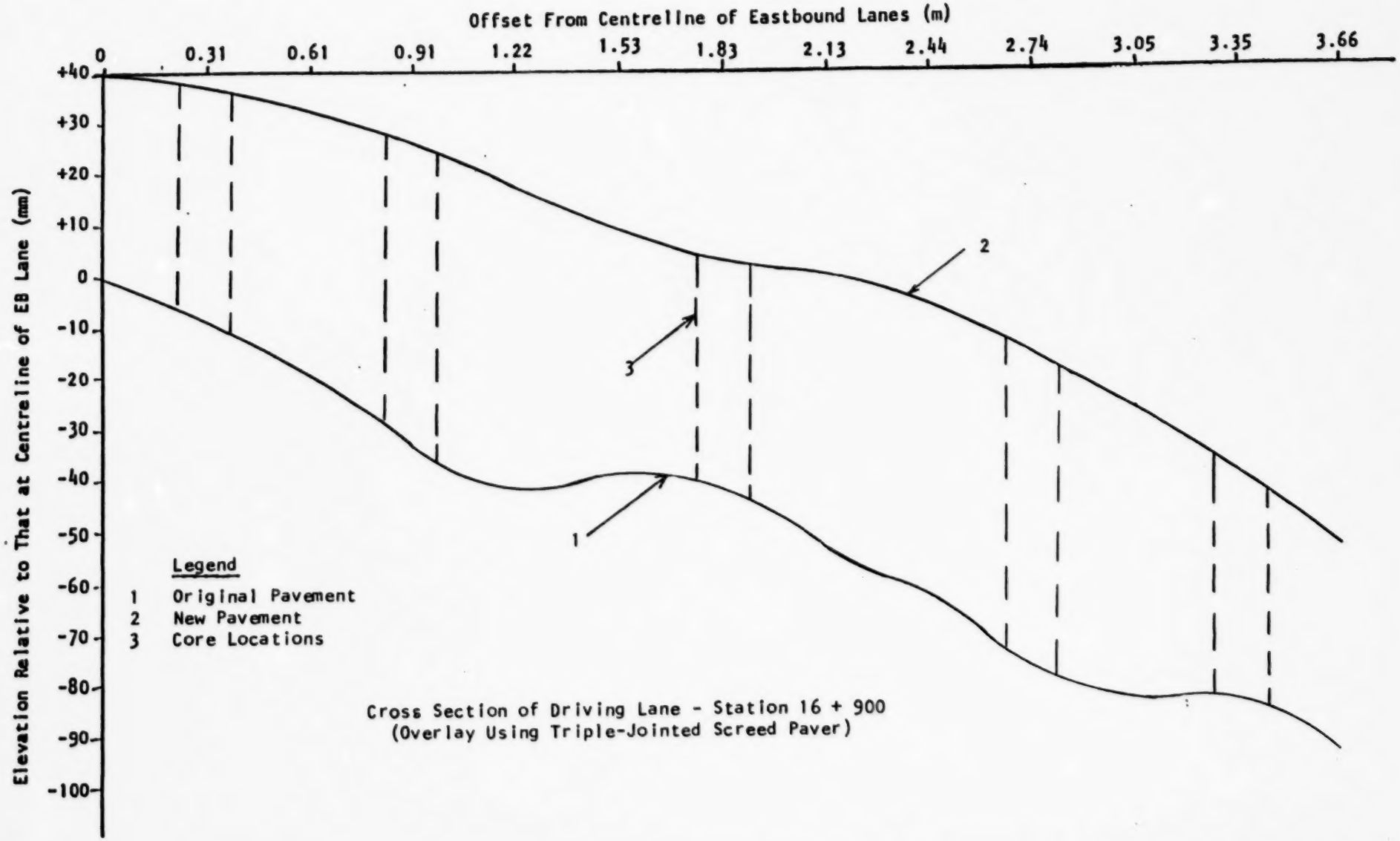
Cross Section of Driving Lane - Station 16+350
(Using Triple-Jointed Screed Paver)



Cross Section of Driving Lane - Station 16 + 550
(Overlay Using Triple-Jointed Screed Paver)



Cross Section of Driving Lane - Station 16 + 650
(Overlay Using Triple-Jointed Screed Paver)



Cross Section of Driving Lane - Station 16 + 900
(Overlay Using Triple-Jointed Screed Paver)

APPENDIX 4 - GYRATORY TESTING MACHINE RESULTS

VP (kPa)		346			551			829 kPa		
REV	30	60	90	30	60	90	30	90	300	500
SAMPLE										
1-1	2.382	2.425	2.447							
1-2				2.424	2.465	2.486				
1-3							2.444	2.512	2.576	2.597
2-1	2.407	2.450	2.473							
2-2				2.417	2.460	2.484				
2-3							2.433	2.504	2.574	2.600
3-1	2.393	2.440	2.463							
3-2				2.438	2.484	2.509				
3-3							2.452	2.518	2.578	2.598
4-1	2.417	2.461	2.485							
4-2				2.446	2.486	2.508				
4-3							2.449	2.516	2.579	2.602
AVER	2.400	2.444	2.467	2.431	2.474	2.497	2.445	2.513	2.577	2.599

Sample Bulk Relative Density (g/cm^3)

VP (kPa)		346			551			829 kPa		
REV	30	60	90	30	60	90	30	90	300	500
SAMPLE										
1-1	21.0	42.5	60.4							
1-2				130.0	160.0	179.0				
1-3							178.0	229.0	385.0	444.0
2-1	37.8	66.4	91.5							
2-2				100.0	130.0	159.0				
2-3							156.0	196.0	350.0	433.0
3-1	50.0	64.9	75.9							
3-2				124.0	137.0	152.0				
3-3							169.0	213.0	315.0	368.0
4-1	10.4	31.5	39.0							
4-2				126.0	143.0	172.0				
4-3							195.0	221.0	326.0	375.0
AVER	29.8	51.3	66.7	120.0	142.5	165.5	174.5	214.8	344.0	405.0

Sample Shear Strength (kPa)

* VP = Vertical Pressure

VP (kPa)		346			551			829	kPa	
REV	30	60	90	30	60	90	30	90	300	500
SAMPLE										
1-1	1.000	1.000	1.000							
1-2				1.038	1.019	1.000				
1-3							1.000	1.019	1.019	1.019
2-1	1.000	1.000	1.000							
2-2				1.000	1.038	1.019				
2-3							1.000	1.040	1.040	1.040
3-1	1.000	1.000	1.000							
3-2				1.040	1.000	1.040				
3-3							1.000	1.000	1.020	1.000
4-1	1.019	1.019	1.019							
4-2				1.061	1.040	1.020				
4-3							1.020	1.020	1.040	1.020
AVER	1.005	1.005	1.005	1.035	1.024	1.020	1.005	1.020	1.030	1.020

Sample Gyratory Stability Index (kPa)

VP		346			551			829	kPa	
REV	30	60	90	30	60	90	30	90	300	500
SAMPLE										
1-1	.1907	.3855	.5483							
1-2				.7415	.9147	1.0240				
1-3							.6754	.8710	1.4610	1.6820
2-1	.3435	.6027	.8303							
2-2				.5734	.7432	.9109				
2-3							.5945	.7460	1.3260	1.6420
3-1	.4537	.5887	.6886							
3-2				.7076	.7821	.8700				
3-3							.6435	.8085	1.1950	1.3960
4-1	.0948	.2862	.3537							
4-2				.7224	.8161	.9845				
4-3							.7391	.8396	1.2360	1.4240
AVER	.2707	.4658	.6052	.6862	.8140	.9474	.6631	.8163	1.3045	1.5360

Sample Gyratory Shear Factor

* VP = Vertical Pressure